Effective Voyage Planning

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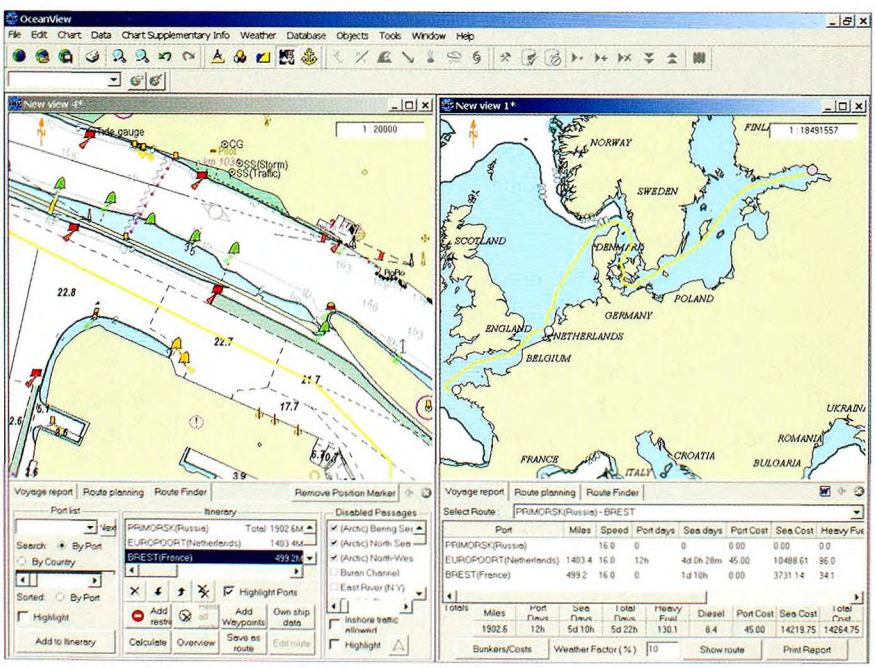
This article describes a research project of the first automatic voyage planning system that may be considered as one of the major innovations in the ECDIS technology since the adoption of the IMO Assembly Resolution A.817 (19).

In 1995 the IMO adopted the performance standard for ECDIS. The expected result of its introduction, as underlined by IMO, is the reduction of workload for the mariners and, as a consequence, increased safety of navigation. Indeed, ECDIS performs much of the routine work, such as the plotting of the vessel's position on the chart, manual and automatic route monitoring, and it also improves the quality of the navigator's work thanks to the automatic generation of alarms when approaching charted hazards and deviating of the planned route. However, Voyage Planning still requires a lot of manual work due to the absence of specialised data- and knowledge bases.

Theoretically, the task of route optimisation can be defined as the minimisation of the criterion function (the integral voyage cost for a commercial vessel or the time to approach the target for tasks such as SAR operations). The parame-



route planning *Automatic voyage planning takes few seconds*

ters to be optimised - waypoints along the route and the speed, can vary within certain limits termed as absolute and conditional limits in the technical cybernetic.

Absolute Limits

The Absolute limits include self-sustaining period and the ship's class insufficient for the intended voyage, the absence of detailed charts, limiting depths, restricted areas, vertical and horizontal clearance of the bridges, the size of the locks, traffic lanes of the opposite orientation, etc.

When these limitations are calculated the own ship's safety zone, which depends upon the dimensions and dynamics of the ship, the accuracy of the ship's absolute position, the status of hydrographic survey of the navigating area (probability of appearance of non-charted obstructions), the absolute accuracy of the navigational charts, allowance for the unplanned (not controlled) alteration of the ship's movement, must be considered. We intentionally underline the terms 'absolute position' and 'absolute accuracy of charts' to highlight the importance of this factor for the modern GPS navigation.

Conditional Limits

Conditional limits include fishing zones, areas with high pirate activity, territorial and inland waters requiring a preliminary agreement for entry /passage of foreign vessels, inconsistency of the GMDSS equipment onboard with the actual coverage of GMDSS stations, the absence of an agreement (co-ordination) regarding the route with SAR centres (mandatory requirement for the large passenger ships according to chapter 5 SOLAS), necessity of ice-breaker assistance to pass a route segment covered by ice, the improbability of receiving timely help from passing vessels and SAR centres in case of emergency, etc.

Main Factors

The main factors affecting the selection of the route and its schedule, with the consideration of the limitations listed above, are: the route distance, the direction and strength of the currents, seasonal winds, meteorological forecast, tides, the cost of channel's passage, the statistical estimations of speed limitations in narrow waters and in the areas of heavy traffic considering the variations of day/night conditions and meteorological visibility, necessity of using the shore based aids to navigation and/or radar to check the GPS etc.

The development of an automated system, which allows the solution to the tasks described effectively and reliably, requires complete databases and an efficient system for their updating.
Considering the global nature of shipping only those databases that provide global coverage are of a real value.

A special production line is developed and set up to process databases information and synchronise its updates together with the updating of CM93/3 electronic charts. The kernel database is the multi layered planar graph that connects approximately 5,000 ports world-wide. Evristic algorithms allow quick calculation of the route that would best match applied criteria taking into account ship's parameters, information from supplementary databases and rules for passing of traffic separation schemes. The navigator can specify particular 'feeder' waypoints or channels to pass through, and also create a number of alternative routes by disabling certain navigation areas.

Calculation of a route of any complexity between any numbers of ports world-wide takes only seconds (2-5 sec). Unlike the tables of distances between ports and recommended routes, the calculation of the route based on the planar graph is highly accurate which enables the mariner to calculate the exact time, fuel consumption including storm reserve and the cost of the voyage with the accuracy that can be only achieved based on the time consuming navigational route planning.

Conclusions

1. Positive result of the project demonstrated that automated voyage planning is possible and very effective
2. Apart from the ECDIS technology, potential applications can include global transport logistics, planning and harmonising of paper charts and ENC production to better match the ship-

ping needs etc. This database, called 'C-Routes', allows generation of various reports such as calculation and graphic presentation of, say, the routes between all medium harbours within an area or world-wide, or the only routes suitable for particular type of vessels and the list of charts intersected by the routes

3. Compilation of necessary databases for voyage planning and keeping them up-to-dated requires first of all the representative global electronic charts coverage. In order to provide quick and reliable calculations of the routes, the chart database should form seamless coverage, and the charts from different Hydrographic offices should be harmonised with each other in terms of provided information. It still happens that recommended routes, dredged areas and even the IMO adopted traffic separation schemas are presented differently on different charts, covering the same area
4. One of the well-known problem is the absence of information about the reliability of navigational charts – the probability of presence of uncharted obstructions and the accuracy of charts. National Hydrographic Offices and the IHO could make the vital contribution in the improvement of safety of navigation by providing the global electronic catalogue of all paper and electronic charts with the references to source data and indication of their accuracy/ survey class. In particular, these data are necessary for calculation of the ship's safety zone, and, in wider view - such database would be the base for many other developments world-wide. For sure, this is one of typical applications where industry could effectively co-operate with IHO and Hydrographic offices

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